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SUPPRESSED SIDELOBE HORN ANTENNA

~~Inventor:~~ Philip D. Potter 15 Jun. 1962 8p Oref

Lloyd Spencer
Patent Counsel

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CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA
June 15, 1962

RQT-12727

CASE NO. 425

INVENTION RECORD

To be submitted to Invention Reports Group

Jet Propulsion Laboratory
California Institute of Technology

1. Inventor name	position & title	P O address and legal residence
Philip D. Potter	Resident Group Supervisor	9447 Haines Canyon Tujunga, California

2. Title of invention SUPPRESSED SIDELOBE HORN ANTENNA

3. Brief Description and Novel Features

By judicious use of the TE^{o}_{11} and TM^{o}_{11} waveguide modes in a pyramidal horn antenna of circular cross section it has been demonstrated both experimentally and analytically that it is practical to produce E and H plane radiation patterns of equal beamwidth. Simultaneously, all sidelobes are suppressed approximately 40 db from the beam maximum. This latter feature represents a fundamental breakthrough in the antenna field. This antenna is simple and easy to construct.

4. Historical Data	date	location
a. conception by inventor	5/9/62	JPL
b. disclosure to others	5/11/62	JPL
c. first sketch or drawing	5/9/62	JPL
d. first written description	5/14/62	JPL Notebook 333-102
e. completion of model or full-sized device	5/11/62	JPL
f. first test or operation of invention	5/11/62	JPL

5. Names of Persons Acquainted With Items 4 thru 7

Frank E. McCrea
Danver Schuster

6. Results of Test
Excellent. Sidelobes suppressed 40db; equal beamwidths in E and H planes

7. Applications and State of Development
Will be used in GS cassegrain antenna system

8. Reference Reports, Publications and Drawings
JPL Notebook 333-102

9. Patents None

10. Licenses None

11. Contract No. NAS 7-100

12. Signatures -- give signature and date, first names in full

a. witnesses

Subscribed and sworn to before me this 12th day of June 1962

Notary Public in and for the County of Los Angeles, State of California

My Commission Expires May 17, 1963

b. inventors

Philip D. Potter

Date

JPL 60-096

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SUPPRESSED SIDELOBE HORN ANTENNA

This invention relates to microwave antennas and more specifically to a microwave antenna with improved radiating characteristics.

When microwaves are radiated by means of horn antennas it has been the practice to allow only one mode, such as the TE^{O}_{11} or TE_{01} mode (O and refer to circular and rectangular waveguides), to propagate and to take special care to assure that all other modes are suppressed. This invention provides for the combining of two modes of propagation in such power ratios that the beamwidths of the radiation pattern of the antenna are equalized and sidelobes in the radiation pattern are greatly reduced.

Accordingly, one object of the invention is to provide an antenna having a radiation pattern with greatly suppressed sidelobes.

A further object is to provide an antenna which produces E and H plane radiation patterns of equal beamwidths.

A still further object is to provide a means of altering the relative beamwidths in the E and H planes, of radiation emanating from an antenna.

These and other objects, and a full understanding of the invention may be had by reference to the following description taken in conjunction with the accompanying drawings in which:

Figure 1 is a cross sectional side elevation view of a horn antenna system constructed in accordance with the invention.

Figure 2 is a representation of the radiation pattern for microwaves propagated through a horn in the TE^{O}_{11} mode, and represents the pattern that may be observed from the arrow 2-3 of Figure 1.

Figure 3 is a representation of the radiation pattern for microwaves propagated through a horn in the TM^{O}_{11} mode observed from the arrow 2-3 of Figure 1.

The invention comprises a microwave source 4 connected to a circular waveguide 1 whose end is connected to a transition chanber 2, of circular cross-section, the transition chamber being connected to a circular horn antenna 3. The diameter of the circular waveguide 1 is sufficiently small that microwaves are propagated only in the TE_{11}^{O} mode down the waveguide 1 for the particular microwave frequency used. The diameter of the transition chamber 2 is large enough so that the TM_{11}^{O} mode can propagate in it. The sharp change in cross section at plane 5 causes the generation of the TM_{11}^{O} mode. At the plane of transition 5, both the TE_{11}^{O} and TM_{11}^{O} modes are approximately in phase.

The TE_{11}^{O} and TM_{11}^{O} modes travel with different velocities down the transition chamber 2 and horn 3 and the chamber and horn are made so that the two modes are in phase at the end 6 of the horn. The relative phases of the TE_{11}^{O} and TM_{11}^{O} modes at the end of the horn 6 can be adjusted by varying the length of the transition chamber 2 and horn 3.

When microwaves propagated in the TE_{11}^{O} mode reach free space, power is radiated in many directions as illustrated in Figure 2. However, the width of the main beam 21 along the H plane is wider than along a perpendicular plane referred to as the E plane. When microwaves propagated in the TE_{11}^{O} mode reach free space the radiation pattern is as shown in Figure 3, and the width of the main beam 31 plus 32 along the E plane is wider than the width along the H plane. When both the TE_{11}^{O} and TM_{11}^{O} modes are propagated, the power radiated by each mode adds for each direction. By properly adjusting the relative power propagated in the TE_{11}^{C} and TM_{11}^{O} modes, total power radiated along the E and H planes may be made equal in the main beam region so that the beamwidths are approximately equal along all planes. Alternatively, the beamwidth along the E and H planes can be given various ratios.

The reduction of sidelobes is one of the most important advantages of the present invention. The main beam 21 of waves radiated from the TE_{11}^{O} mode has its greatest amplitude in the direction in which the antenna is pointing. The first sidelobes 22 and 23 are out of phase with the main beam 21 by 180^{O} and are shadowed and labeled with [illegible] them to indicate this fact. The second set of sidelobes 24 and 25 are 180^{O} out of phase with the first set 22 and 23 and this phase change for adjacent sidelobes continues for the rest of the sidelobes. In Figure 3 which shows the radiation pattern for microwaves propagated in the TM_{11}^{o} mode, there are two main lobes 30 and 31 of a certain phase, but the first sidelobes 32 and 33 have the same phase as the main lobes. Other sidelobes alternate in phase as with the lobes of Figure 2. If radiation from the TE_{11}^{o} mode is added to radiation from the TM_{11}^{o} mode, as by adding the radiation patterns of Figure 2 and Figure 3, the main beams 21, 30 and 31 will add while the sidelobes will tend to cancel out each other. By choosing that ratio of strengths of the TE_{11}^{o} and TM_{11}^{o} modes where the sidelobes 22 and 23 of the TE_{11}^{o} mode and 32 and 33 of the TM_{11}^{o} modes are equal, (through 180^{o} out of phase) the sidelobes of the TE_{11}^{o} and TM_{11}^{o} mode will cancel. The main beams 21, 30 and 31 will add while all sidelobes will be suppressed. It should be noted that the relative strength of the TE_{11}^{o} and TM_{11}^{o} modes which yields the most suppressed sidelobes is also the ratio which yeilds equal beamwidths in the E and H planes.

The actual dimentions of the transition chamber 2 and horn 3 can be determined experimentally for the particular frequency which the antenna will radiate. The length L of the transition chamber 2 may be adjusted until the TE_{11}^{o} and TM_{11}^{o} modes are in phase at the end of the horn 6; the length and angular opening of the horn 3 also has an effect on phase. The relative intensities of the TE_{11}^{o} and TM_{11}^{o} modes can be altered by varying the diameter D of the transition chamber. In particular, it has been found that sidelobes can be greatly suppressed and equal beamwidths obtained along the E and H planes for a frequency of 9600 megacycles when W=1.25, D=1.60"; 0–6°, L=0.25", and Y=5.4"; where W is the diameter of the waveguide 1, D is the diameter of the transition chamber 2, 0 is the angular opening of the horn 3, L is the length of the transition chamber 3, and Y is the diameter of the mouth 6 of the horn 3.

One purpose of the transition chamber 2 is to suppress undesirable modes at the transition plane 5 because the limited diameter of the transition chamber 2 suppresses them. Another purpose of the transition chamber 2 is to provide a simple means of changing the relative phases of the TE_{11}^{o} and TM_{11}^{o} modes at the opening of the horn 6, which can more easily be done by varying the length of the transition chamber 2 than by varying the length and angle of the horn 3.

The combining of the radiation patterns of two modes in a rectangular waveguide system may provide more equal beamwidths and reduce sidelobes, but not as effectively as with circular or eliptical waveguide systems.

The invention does not help suppress sidelobes along the H plane, but these sidelobes are usually very small and there is no great need to suppress them.

One novel feature of the invention is the propagation of at least two modes in a waveguide terminated in an antenna, the main beams of the radiation pattern of the antenna being approximately in phase while some of those sidelobes of the two modes which have overlapping directions in the radiation pattern are sufficiently out of phase that they tend to cancel out one another.

A second novel feature of the invention is an eliptical-circular waveguide and antenna system including an antenna, means for propagating both the TE^{o}_{11} and TM^{o}_{11} modes through said antenna of said system, said system so constructed that the main beams of the radiation patterns of the TE^{o}_{11} and TM^{o}_{11} modes are approximately in phase corresponding sidelobes of the TE^{o}_{11} and TM^{o}_{11} modes are approximately 180° out of phase, and the intensity of said corresponding sidelobes are approximately equal.

A third novel feature is in an eliptical-circular waveguide and antenna system including an antenna, the improvement comprising means for propagating both the TE^{o}_{11} and TM^{o}_{11} modes through said antenna, said system so constructed that the main beams of the radiation patterns of the TE^{o}_{11} and TM^{o}_{11} modes are approximately in phase and power ratio of the main beams is such that the sum of the two radiation patterns yields a main beam having approximately equal beamwidths along the E and H planes of the radiation pattern.

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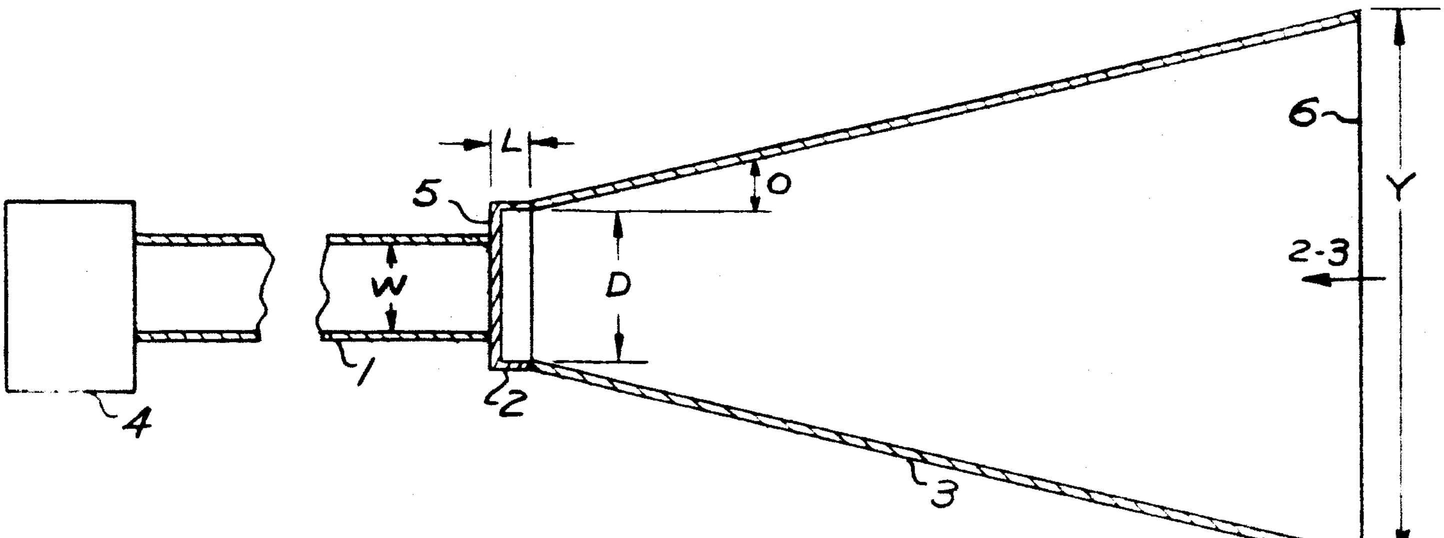

FIG. 1

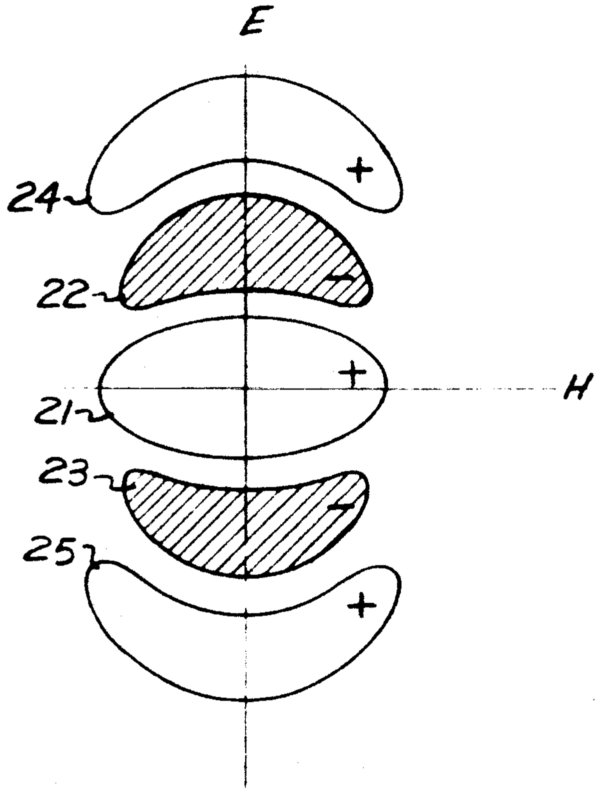

FIG. 2

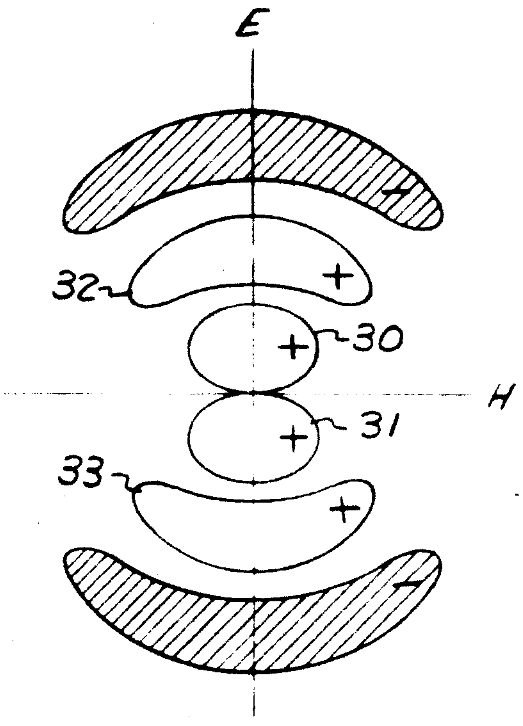

FIG. 3